THE IMPACT RATE ON GIANT PLANET SATELLITES DURING THE LATE HEAVY BOMBARDMENT.
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Introduction: Determining the amount of mass that struck the moons of the giant planets during their helter-skelter youth is crucial for interpreting the histories of these bodies. We have calculated impact rates onto the satellites in the context of the "Nice II" model [1] and find a smaller influx than do others based on the original Nice model [2][3].

Background: Nimmo and Korycansky [3] (henceforth NK12) found that the Late Heavy Bombardment (LHB) of the outer Solar System in the original Nice model would have been a catastrophe for some icy moons. Specifically, the mass striking the satellites at speeds up to tens of km/s would have vaporized so much ice that Mimas, Enceladus, and Miranda would have been devolatilized. NK12's possible explanations of this apparent discrepancy with observations include (1) the mass influx was a factor of 10 less than that in the Nice model; (2) the mass distribution of the impactors was top-heavy, so that luck might have saved some of the moons from suffering large, vapor-removing impacts; or (3) the inner moons formed after the LHB. NK12 calculated the mass influx onto the satellites from the lunar impact rate estimated by [4] and scaling factors calculated by [5],[6]; also see [2]. Production of vapor in hypervelocity impacts was calculated from [7].

Methods: We start with the Nice II model calculated by [1]. In this model, the giant planets start in mean-motion resonance with each other, based on [8]. The planetesimal disk beyond the planets is viscously stirred by 1000 Pluto-mass bodies within the disk. The time at which the planets go unstable, triggering the LHB, is less sensitive to the assumed properties of the disk than in the original Nice model [1]. We estimated impact rates on these planets' satellites both by scaling from direct impacts recorded in [1] and by using a statistical code based on [9] for all planet-crossing bodies in [1].

Results: We find that the mass striking the planets is smaller than inferred by studies using the original Nice model. For example, the results of [2] imply 0.37 Earth masses striking Saturn during the LHB, while we find 0.11 and 0.07 Earth masses using direct impacts and the statistical code, respectively. The smaller planetary impact rates imply that the satellite impact rates have been overestimated by a factor of ~3 [10]. We also find that the planetesimals' encounter velocities with the planets are typically larger than in the present-day Solar System [6], reflecting the eccentric orbits of both the planetesimals and planets.

Conclusion: Icy satellites may survive the LHB. We thank the NASA Lunar Science Institute (http://lunarscience.nasa.gov/) for support.

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